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PHYSIOLOGICAL CHANGES ASSOCIATED WITH CHANGING FIXED RATIO SCHEDULES IN RATS[1]

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Summary.—In two experiments rats, which had been gradually adjusted to a fixed ratio 50 (FR 50) reinforcement schedule over 10 sessions and then suddenly were placed on a FR 125 schedule on Session 11, showed a significant decrease ($p < .05$) in circulating blood eosinophil levels compared to groups which had been similarly shaped up to but maintained on a FR 50 schedule. The changes presumably occurred within a 35- to 40-min. period following the schedule change. Significant positive correlations were noted between the amount of disruption in the response pattern observed in the records of the group that had been shifted from FR 50 to FR 125 and number of fecal boluses on the last day, duration of the bar-press per response, and thyroid-thymus nodule weights.

Performance on reinforcement schedules has been used as a sensitive, reliable baseline for testing the effects of a wide variety of variables, including physiological changes. On the other hand, the investigation of the effects of reinforcement schedules upon physiological changes has been limited mostly to electroshock-avoidance situations (Mason, 1968a, 1968b). Non-electroshock schedules have usually produced little, if any, effect on the physiological responses measured (Mason, Brady, & Sidman, 1957). This may be due in part to the maintenance of the animal on a static reinforcement schedule program before the physiological response was measured. Halasz (1968), who has applied control-system concepts to behavioural systems, has argued that important organismic changes may exist as *response transients* to schedule changes. It was decided to investigate the possible effects of abrupt changes in reinforcement schedules on some selected physiological responses.

METHOD

Animals and Apparatus

In Exp. I, 21 naive female albino Holtzman rats ranging in age from 3 to 5 mo. were used as *S*s, while in Exp. II, 36 60-day-old naive male Holtzman rats were selected. Four ventilated, commercial, operant chambers were used. Each chamber had a metal lever 2.5 cm long, requiring an average force of 6.5 gm to activate a microswitch, mounted on one wall of the chamber 4 cm above the floor. Reinforcement consisted of 45-mg Noyes food pellets automatically dispensed into a receptacle located 6 cm to the left side of the lever.

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Illumination was provided by a 7-w light in the experimental chamber. The programming and recording equipment were placed in an adjoining room.

Procedure

Four days prior to the beginning of each experiment, *S*s were deprived of food until each of their predetermined 80% free-feeding weights had been reached. In Exp. I, weight was maintained at this value throughout the duration of the experiment, while in Exp. II the growth of *S*s was taken into account by adding 3.3 gm daily to the free-feeding weight before the 80% value was calculated. *S*s in Exp. I were then assigned to three conditions: CRF (continuous reinforcement), FR (fixed ratio) 50, or FR 50-125, the number of *S*s in each condition being 8, 6, and 7 rats, respectively. These animals were trained and tested over a 2-mo. period in three sub-experiments, 7 animals per sub-experiment. The 36 male rats in Exp. II were assigned, equalizing for free-feeding body-weight differences, to four conditions (9 rats per condition): CRF, FR 50, FR 50-120, and FR 50-125 control. During the 11 consecutive daily sessions of the two experiments, the CRF groups received reinforcement for every lever press, while the FR 50 groups were adjusted to and maintained on a fixed-ratio schedule in which one pellet was received every 50 lever presses. On Days 1 to 11, the schedules were CRF, CRF, FR 2, 4, 8, 16, 25, 35, 50, 50, and 50. The FR 50-125 groups were also adjusted to and maintained on a FR 50 schedule, but on the final (11th) day of the experiment the schedule was changed to FR 125. Over the 11 sessions each *S* in the FR 50-125 control group (Exp. II) was not required to press a lever for food reinforcement but was placed in one of the chambers along with a small dish containing the number of pellets that the previous FR 50-125 rat had received. *S*s remained in the chambers for 30 min. per session; total responses, fecal boluses, time spent pressing the bar, and cumulative responses were recorded. Within 5 min. following the termination of the last session, *S* was then taken to surgery and decapitated with a guillotine. Adrenals (Exp. I only), thyroids and thymus nodules, testicles (Exp. II only), and spleens (Exp. II only) were weighed (wet weights) on a Sartorious balance. Blood was drawn from the collected pool into a blood diluting pipette for determination of circulating blood eosinophil levels by a medical technician in hematology (V.K.). The sample was treated as outlined by Miale (1967) while the counting procedure has been described by Wintrobe (1956). Blood sugar levels were also measured.

Results and Discussion

In the first experiment, the CRF, FR 50, and FR 50-125 groups averaged 29.0, 22.0, and 9.8 counts, respectively, while in the second experiment the CRF, FR 50, FR 50-125 and FR 50-125 control groups averaged 23.3, 31.2, 20.2, and 24.0 counts of circulating blood eosinophils respectively. These differences were

found by analysis of variance to be significant beyond the .05 level ($F = 5.03$, $df = 2/18$; $F = 3.48$, $df = 3/32$, respectively). Individual t tests indicated that in Exp. I the significant difference was between the CRF-FR 50 and FR 50-125 groups while in the second experiment the main difference was between the FR 50 and FR 50-125 groups only.

No significant differences were found between groups with respect to testicle, adrenal or spleen weights. In Exp. II, thyroid-thymus nodule weights were significantly ($F = 6.05$, $df = 3/32$, $p < .01$) lighter for the FR 125 group relative to the FR 50 group. Blood sugar levels varied between groups in a significant ($p < .01$, $F = 5.92$, $df = 3/32$) manner but were related to number of food pellets received. Response-disruption scores were obtained by ranking the individual cumulative records from the last session of the FR 50-125 group from least to most disturbance of smooth FR response rate and as a function of the amount of between reinforcement pauses (not post-reinforcement pauses). Disruption scores were then correlated with the various behavioural and physiological measures. In the second experiment, significant rank correlations ($p < .05$) were found between response disruption on the day of the schedule change and the number of fecal boluses on the last day (.77), time spent pressing the lever (.83), and thyroid-thymus nodule weights (.78).

The observation that the CRF and FR 50-125 control groups showed variable counts of circulating blood eosinophils in the two experiments and were similar in fact to the FR 50-125 (response-disruption) group, does not necessarily reduce the importance of the results. In terms of stimulus operations performed on the organism the FR 50 and FR 50-125 (response-disruption) groups were closest and had the most similar reinforcement history, except for the last day. Consequently the difference on the last day between FR 50 and FR 50-125 groups might be interpreted as being due to the reinforcement change, while the values for blood eosinophil counts in the other groups which had relatively dissimilar reinforcement histories could be related to different variables.

The possibility that more long-term effects following disruptions of reinforcement schedules may exist has some interesting implications. If the models of Halasz (1968) are correct, behavioural and physiological systems should show considerable oscillation for some days after a step-like change in schedule. We have been impressed with the observations that rats maintained in the Department's colony frequently develop respiratory infections following severe "ratio strain." A relationship between reinforcement-schedule changes and varying susceptibilities to diseases has been suspected. That the decrements in circulating eosinophils reflect varying disease susceptibility remains to be verified. However, we think that systematic investigations of the relationships between various schedule changes and physiological responses with immunological implications, may be quite informative.

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